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REDESCRIPTION AND ECOLOGICAL NOTES ON THE PYGMY BLUETONGUE, *TILIQUA ADELAIDENSIS* (SQUAMATA: SCINCIDAE)

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Summary

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A preliminary study of a population of the pygmy bluetongue, *Tiliqua adelaidensis* (Peters, 1863) has enabled us to redescribe the species and give a preliminary account of its natural history. Life colouring, intrapopulation variation, sexual dimorphism and general morphology of the skull and mandible are described. Pygmy bluetongues at the study site are diurnal inhabitants of open tussock grassland and use spider holes for shelter. Males had enlarged turgid testes during spring and a female examined at this time had yolked ovarian follicles. Males were more active and trappable than females during spring, but both sexes were sedentary during late summer-autumn. Litters of 1-4 live young were born in the maternal burrow during February-March. We suggest that the lack of sightings of *T. adelaidensis* this century has been due partly to its specialised ecology and partly to a real decline attributable to habitat destruction.

KEY WORDS: *Tiliqua*, Scincidae, lizards, morphology, natural history, conservation.

Introduction

"kommt nur auf sandigem, steinigem terrain vor" (Richard Schomburgk, quoted by Peters, 1863).

Schomburgk's remark ("found only in sandy, stony terrain") is the only published first-hand information available on the ecology of *Tiliqua adelaidensis*, the pygmy bluetongue lizard, a species which has been regarded as one of the most seriously endangered of Australia's reptile species, if not actually extinct (Cogger 1992; Ehmann 1992; Hutchinson 1992). The discovery of a population of the species near Burra, S.A. (Armstrong & Reid 1993; Armstrong *et al.* 1993), following the first sighting of the species for 33 years, has presented an opportunity for urgently needed study of the species which had previously been known from only 20 museum specimens, mostly collected last century (Ehmann 1982; Shea 1992).

The original description (Peters 1863) was brief, based on two syntypes probably collected in the vicinity of Gawler, S.A. Mitchell (1950) redescribed the species based on SA Museum specimens and figured the head shields and whole animal for the first time. No further formal descriptions have appeared in print, save for those of Cogger (e.g. 1975, 1992), based on the old and faded museum material. Shea (1990) described a number of scalation and osteological character states for *T. adelaidensis* in order to establish the validity of the genera *Tiliqua* and *Cyclodomorphus*. Shea's unpublished thesis (1992[1]) gives a thorough description of the species' scalation, morphometrics, colour pattern and osteology based on the twenty specimens then extant. Shea & Hutchinson (1992) illustrated and commented on the dentary and dentition of *T. adelaidensis*.

Ehmann (1982) summarised available data on diet and external morphology and drew together the meagre data bearing on the provenance of the specimens known to him. He also attempted to reconstruct the species' ecology, using analogies with related or physically similar reptile species. These speculations were cited several times subsequently, sometimes in such a way that it was not clear that there were no direct observational data on the subject (Ehmann 1992).

Field work has begun, aimed at determining the best methods for locating *T. adelaidensis*, gathering preliminary data on its ecology and making a first attempt to determine the number and size of surviving populations. This article gives a summary of the morphological variation that we have observed within a single population of *T. adelaidensis* and provides a preliminary account of its natural history at this site.

Methods

Current research on the biology and conservation of this species is concentrated on one site located in the Burra area (33°41'S, 138°56'E), approximately 160 km north of Adelaide, South Australia. The site was the first of several found to support *T. adelaidensis*, following the initiation of fieldwork in October, 1992

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[1] SHEA, G. M. (1992) The systematics and reproduction of bluetongue lizards of the genus *Tiliqua* (Squamata: Scincidae). Unpub. PhD thesis, Dept of Veterinary Anatomy, University of Sydney.

(Armstrong *et al.* 1993). The data presented here stem from the first season of field work on this population, carried out from mid-October 1992 to mid-May, 1993.

Specimen Collection

Live *T. adelaidensis* were collected by three methods.

Pitfall traps. 30 metre stretches of fly wire drift fencing were erected, along which were placed six 25 cm lengths of PVC pipe dug vertically into the ground. Four traplines were set at the study site during the period 4 November-20 December, 1992. An additional line was in place during 30 November-20 December and a further two were set on 4 December. The five most successful spring traplines were reset during 2-21 February 1993. Total trap nights by this method were 1,956.

The other two methods relied on the species' hole-dwelling habits (see *Habitat* section).

Hand collection. This method relied on opportunistic sightings of free ranging animals, or on surprising animals at the entrances to burrows. Most individuals caught by hand were juveniles which were extracted from burrow entrances using long forceps or clamps.

We also used a method we termed "fishing", enticing lizards to seize an insect bait tied to a cotton thread. A grasshopper on a piece of cotton tied to the end of a three metre bamboo pole was held outside the entrance of the lizard's burrow; lizards seizing the grasshopper could be pulled into the air and captured as they dropped to the ground and tried to return to the burrow (Strong *et al.* 1993 describe a similar collection technique). Lizards had to be lured completely out of the burrow before being allowed to seize the grasshopper, since the lizard's hind limbs could hold the burrow rim, preventing its dislodgment. Their extreme wariness made the use of a long pole necessary to distance the collector from the lizard.

Trapping using baited (peanut butter or sardines) aluminium "Sherman" traps was tried but without success (approximately 2,500 trap-nights).

The time of day of collection was noted, as was the daily maximum temperature. Lizards were measured and sex was determined by the presence of bulges at the base of the tail and/or hemipenes in males, with a lack of these features indicating a female. The lizards were then marked by toe clipping, photographed and released. Only one or two toes were removed, this limited number in conjunction with colour pattern variations being sufficient to identify each individual.

Limited use was made of radiotracking using a small external unit supplied by Transceiver Services, Adelaide, attached using superglue and surgical tape to the lizard's shoulder. The device was intended for short term use, and was run successfully on a single lizard, located every two hours, for six days. A second trial resulted in the death of the lizard within the first two-hour period and use of this approach was discontinued.

In the descriptive section, scale features occurring bilaterally were counted on both sides. Paravertebral scales were counted using Greer's (1982) method.

Vegetation was quantitatively assessed around the most successful pitfall line using two methods:

a) We recorded all plant species in a 30 m × 30 m quadrat, 15 m either side of each pitfall line, taking collections of plants in cases where identity was not clear. These collections were subsequently identified and lodged with the State Herbarium.

b) We assessed vegetative cover within the 30 m × 30 m quadrats by the simple transect method known as "Step-point" (Cunningham 1975). At every step in set directions across the quadrat we recorded the plant species encountered at the tip of the shoe, scoring approximately 300 points in the quadrat. This method gives estimates of percentage of ground cover of plant species, bare ground, rock and litter.

The behavioural data we present stem mainly from field observations, but we obtained confirmatory data in many cases from observations of captive specimens at Adelaide Zoo (T. Morley and R. Ainsley pers. comm.).

Description

Specimens

The following descriptive section is intended to show variation within a single population. Earlier authors (Ehmann 1983; Mitchell 1950) give additional data from some of the older specimens, and all of the available data on this older material is discussed in Shea's thesis.

A total of 63 specimens was collected during the survey period, and an additional four were born in captivity. Six of these specimens were collected dead, killed by the elapid snake *Pseudonaja textilis* (four specimens) or birds of prey (two specimens). A seventh, R40838, died during trials of an external radio transmitter. Four specimens, an immature, an adult male and two adult females, were retained and are on loan to Adelaide Zoo. The remainder were marked and released. The success of collection methods varied according to time of year. Pitfall trapping was successful only during November-December, while hand collection became much more successful in February-April (Table 1).

All predator-killed specimens are damaged, although in two the damage was minor and confined to restricted areas of the body. R40687 and R40744 had some necrotic patches on the dorsal and ventral body surface. R40687 had a sagittal fracture of the skull running from the rostral scale to the level of the eye. R40689 had the left neck and posterolateral region of the skull deeply gouged and partly removed and a deep wound in the right side of the neck. R40728 lacked the head and right forelimb, as well as the liver, heart, lungs and stomach. R40738 and R40745 were partly digested, with the skin on the body sloughing away and much of the internal soft anatomy missing. Two skulls and associated mandibles were prepared from snake-killed specimens, one articulated (SAMA R40738) and one partly disarticulated (R40745).

TABLE 1. *Relative success of capture techniques.*

Method	Number caught November-December	February-May
Pitfalls	17	nil
Hand	5	21*
"Fishing"	not used	14

* All but one neonates

General Appearance

Tiliqua adelaidensis is a moderate sized skink with short extremities, a relatively heavy body and large head. The body and tail are soft and flexible, but the head is heavily armoured by the well developed head shield osteoderms. The toes are short, the third and fourth toes of the hind foot being equal in length. The tail tapers rapidly from the base and is thin and slightly laterally compressed over the distal two-thirds.

Colour

The dorsal surface of the head, body, limbs and tail is light grey brown, yellowish brown, orange, tan or chocolate brown, the distal portions of the extremities, especially the forelimbs, being a paler yellowish hue. Dorsal and lateral scales usually have narrow darker edges producing fine, longitudinal lines along the back and sides. The lower lateral surfaces are pale greyish becoming off-white ventrally. The dorsal surface is unmarked, or shows variable development of blackish spotting, including a vertebral series of irregular small blotches (which may coalesce into a ragged vertebral stripe) from the nape to the base of the tail, and several laterodorsal and upper lateral series of small black flecks; these may be crudely aligned to form weak transverse bars. The midlateral region often has scattered grey-white flecks. The venter is immaculate, or with slightly greyer margins to the scales forming narrow longitudinal lines. The iris of the eye is bright orange. The tongue is pale rose pink, with no trace of melanic pigmentation. The roof of the mouth and buccal commissures are mauve. The abdominal peritoneum is black. Juveniles are consistently greenish grey to mid-brown, becoming reddish tan on the tail and limbs. The range of variation in black pigmentation is similar to that seen in adults, but many juveniles have more extensive and obvious white spotting on the body.

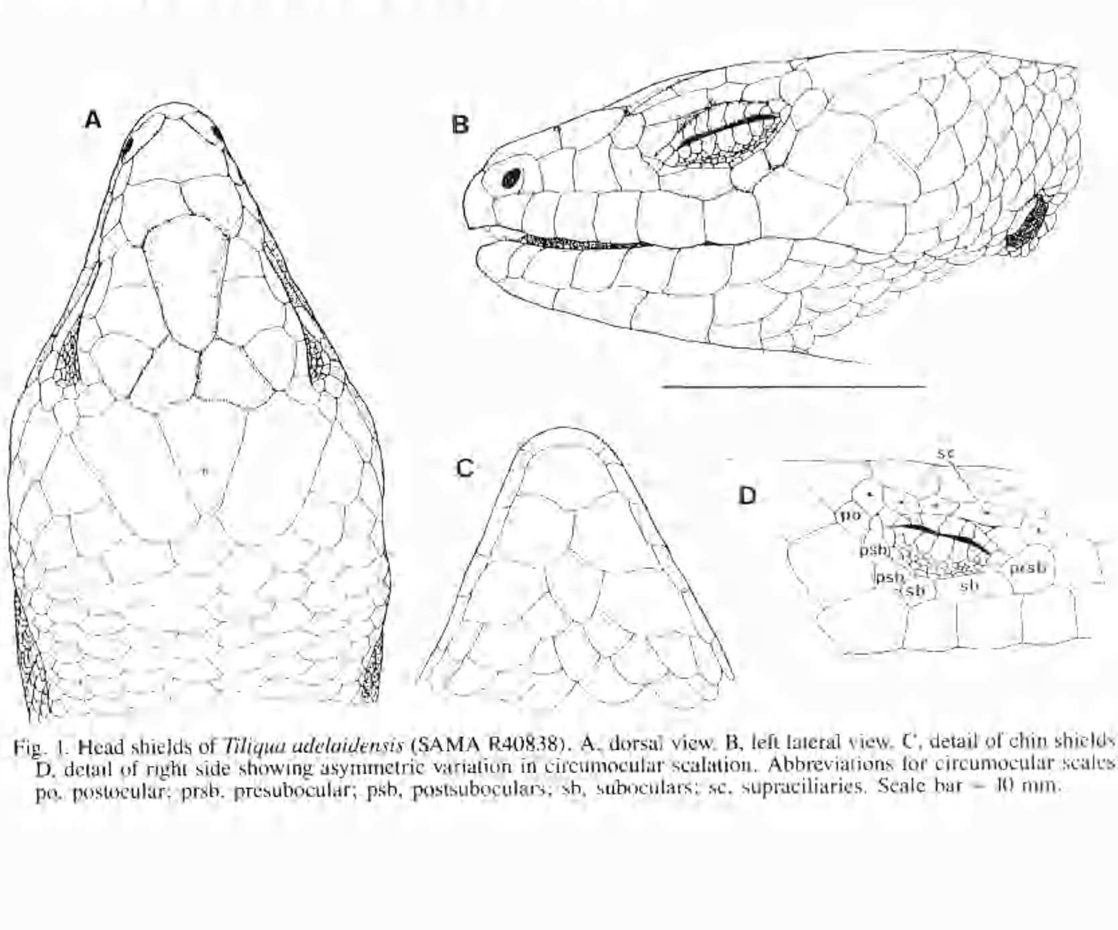
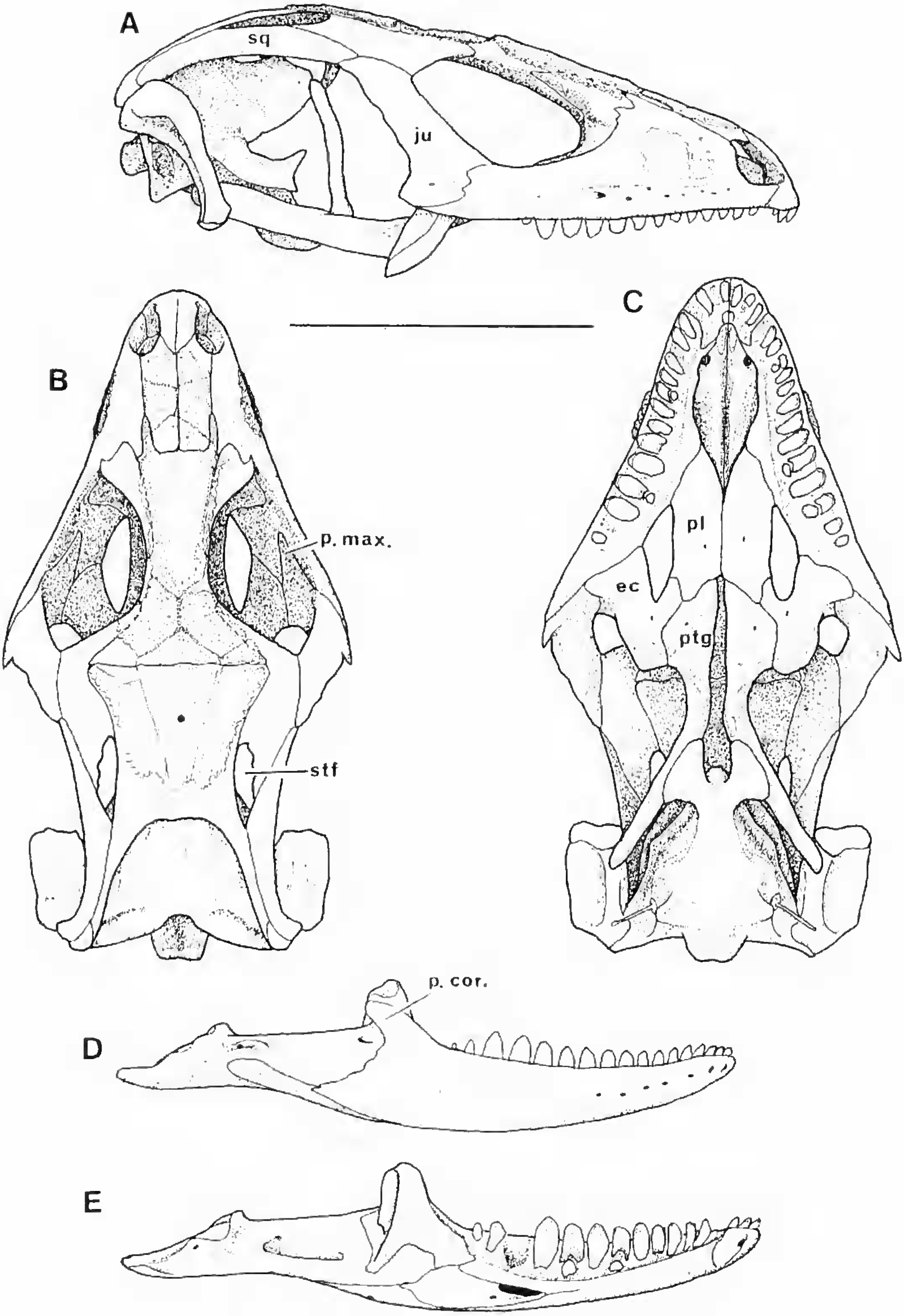


Fig. 1. Head shields of *Tiliqua adelaidensis* (SAMA R40838). A, dorsal view. B, left lateral view. C, detail of chin shields. D, detail of right side showing asymmetric variation in circumocular scalation. Abbreviations for circumocular scales: po, postocular; prsb, presubocular; psb, postsuboculars; sb, suboculars; sc, supraciliaries. Scale bar = 10 mm.


A
sq
ju
B
p. max.
stf
C
pl
ec
ptg
D
p. cor.
E

Scalation

This is based on eight specimens, four held in the S.A. Museum (R40687, R40689, R40744 and R40838), plus a live adult male, two adult females and subadult held at Adelaide Zoo. The head shields are shown in Fig. 1.

The species has the scalation characteristics listed by Shea (1990) for *Tiliqua*. The last supralabial is horizontally divided, and the temporal scalation posterior to the secondary temporals is irregular and little differentiated from the body scalation. The supraciliary scale count is reduced (mode 5). A complete subocular scale row, consisting of a large presubocular, a larger anterior and smaller posterior subocular and one or two postsuboculars, runs from the anterior supraciliary to the postocular. Nuchals are absent or a single slightly enlarged pair may be present, often separated by a median occipital or internuchal scale.

Dorsal scales smooth, in 33-36 (mean 34.6) rows at midbody; paravertebral scales 77-86 (mean 83.0); paravertebral scales between parietal and the level of anterior edge of hind limb 70-81 (mean 77.6); subdigital lamellae under fourth toe unpaired, 10-13 (mean 11.6); nasals in point contact or narrowly separated (0.2); strong postnarial groove present; prefrontals in broad contact; frontoparietals paired; interparietal about same size as frontal, much larger than frontoparietals and separating parietals; each parietal in contact anterolaterally with the postocular and posterior supraciliary and bordered posterolaterally by four or five enlarged scales; a median occipital scale present or absent (0.4) posterior to interparietal; supraoculars 3/3, the first two contacting the frontal; supraciliaries 5/5 (5/6 in one specimen), the second the longest; complete subocular scale row present; supralabials 8, the eighth only half as high as the seventh; infralabials 7-9 (mean 7.9); a single primary temporal is followed by three secondary temporals; postmental contact first two infralabials; a single large, quadrangular anterior ear lobule.

The dorsal head shields, frontonasal, prefrontals, frontal, frontoparietals and interparietal, are thickened, with weakly corrugated surfaces and deeply incised sutures. This rugosity increases with size. In large males the subocular scales also become thickened and slightly overhang the suborbital supralabials.

Skull and mandible

The characteristics noted for the species by Shea (1990; 1992[1]) are confirmed in the SAMA specimens. The species has moderately narrow separation of the pre- and postfrontals on the medial orbital margin. Finger-like nasal processes of the frontals are present to give a W-shaped frontal-nasal contact. The jugal is broad and flattened and contacts the postfrontal. A lacrimal bone is absent. There is a well-developed medial palatine process of the ectopterygoid which excludes the pterygoid from the edge of the infraorbital vacuity. The coronoid process of the dentary is enlarged and swept back to cover the lateral face of the dorsal process of the coronoid. Dentition is heterodont, with the cheek teeth markedly larger than the anterior teeth.

In general aspect (Fig. 2), the skull and mandible of *T. adelaidensis* are very like those of other *Tiliqua* species. The proportions of the snout, tapering and pointed, rather than blunt and rounded, and the parietal region, constricted, rather than laterally expanded, resemble those of adults of the other species of *Tiliqua*. The dorsal head shield osteoderms are intimately fused with the bones of the skull roof, to a greater degree than is usual in most other *Tiliqua*. Thus, even though *T. adelaidensis* is as small as or smaller than congeneric neonates, it is ontogenetically advanced in its proportions and degree of ossification. In these features *T. adelaidensis* is progenetic, not neotenic as is frequently the case in miniaturised lizards (Rieppel 1984). Even so, *T. adelaidensis* also shows some neotenic features in retaining relatively large upper temporal fenestrae and in some aspects of braincase anatomy (Shea pers. comm.).

Unique or unusual features of the skull are few but include the very closely apposed, almost parallel palatal rami of the pterygoids. In most other *Tiliqua* (*T. gigas* is an exception) the pterygoid margins are more widely separated and diverging. The closely apposed pterygoids may be correlated with a narrowing of the skull posteriorly as *T. adelaidensis* has the greatest skull width across the jugals, rather than at the level of the quadrates. The maxillary process of the jugal tapers rapidly and fails to contact the prefrontal. This character state is shared with *T. multifasciata* and most *T. occipitalis*, whereas other *Tiliqua* species have the jugal extending anteriorly to contact the prefrontal adjacent to the lacrimal foramen.

Fig. 2. Skull and mandible of *Tiliqua adelaidensis* (SAMA R40738). A, skull, right lateral view, showing contact between jugal (ju) and squamosal (sq) bones. B, skull, dorsal view, showing short maxillary process of the jugal (p. max.) and open supratemporal fenestrae (stf). Note persistent head shield osteoderms which obscure sutures of prefrontal and postfrontal bones; other skull roof sutures are visible through the osteoderms. C, ventral view, showing configuration of the palatal complex (ec, ectopterygoid; pl, palatine; ptg, pterygoid). D, right mandibular ramus, labial view, showing very well developed coronoid process of the dentary (p. cor.). E, left mandibular ramus, lingual view. Scale bar = 10 mm.

The upper temporal fenestrae are relatively larger than in adults of other *Tiliqua* species, in which they are slit-like or absent.

Dimensions

Based on 61 specimens. Snout-vent length (SVL) 38-107 mm (mean 73.2). Axilla-groin length (AGL) 23-67 mm (mean 44.0, n = 58). Snout-axilla distance (SAD) 16-41 mm (mean 28.3, n = 58). Forelimb length 11-21 mm. Hind limb length 11-21 mm. Tail length (TL) 22-79 mm.

Sexual Dimorphism

Adult males and females (arbitrarily defined as >85 mm SVL) differ markedly in head and body proportions. Adult males on average are shorter than females (SVL males range 87-106, mean 93.4, n = 17; females range 88-107, mean 98.3, n = 14) but head size does not overlap (SAD/SVL males 0.36-0.42, mean 0.38, n = 17; females 0.30-0.35, mean 0.33, n = 14). The relatively large head size of males is a frequent phenomenon in skinks (e.g. Simbotwe 1985; Hutchinson *et al.* 1989; Hutchinson & Donnellan 1992) but is rarely as marked as it is in large adult male *T. adelaidensis*. Male combat has been recorded in other *Tiliqua* species (reviewed by Greer 1989), a selective pressure which might lead to their large head to body ratios.

Ecological Notes

Habitat

The main study site lies at an elevation of about 500 m on undulating terrain cut by small, intermittent stream courses. The ground is stony in places, with underlying shale and sandstone bedrock just exposed on the surface. The soil is hard-packing clay-sandy loam (red-brown earth, French *et al.* 1968). The vegetation of the main trap site is characteristic of degraded remnant native grassland, with the area around the site being bare of trees and shrubs (Table 2). A full list of plant species is provided in the Appendix. The exact original nature of this grassland is unclear, as copper mining and farming near the site since 1845 may have resulted in the removal of trees and shrubs for both industrial and domestic use. Similar hilly areas in the district support *Allocasuarina verticillata* (drooping she-oak) low open woodland over similar ground cover of native grasses (*Stipa* spp., *Danthonia* spp.) and mat-rush or "irongrass" (*Lomandra* spp.), as recorded in the survey area. Jessup (1948) concluded that at least some of the area had probably been essentially treeless prior to European settlement.

TABLE 2. *Ground cover at* Tiliqua adelaidensis *study site (averaged over three quadrats).*

	% Cover	No. Species
Vegetation		
Native Annual	<1	1
Perennial	22	32
Introduced		
Annual	56	18
Perennial	14	2
Bare Ground	3	
Rock	4	
Litter	<1	

The relative abundance and species composition of native grass species varies within the study area. The immediate vicinity of the most productive trapline was dominated by one species of spear grass (*Stipa*, tentatively identified as *S. eremophila*), but elsewhere in the same paddock, pygmy bluetongues were found where *S. nodosa* was the common spear grass, and other grasses, notably wallaby grasses, *Danthonia* spp., and wire grass, *Aristida behriana*, were locally common. Thus the precise species composition of the understorey may be less important for the survival of pygmy bluetongues than the tussocky structure which provides ground cover throughout the year. Other areas surveyed in nearby paddocks which do not appear to support pygmy bluetongues showed increased ground cover by introduced plant species, and hence a decrease in the amount of cover during late summer-autumn. Even at the least disturbed part of the study site, only 50% of the ground cover is perennial vegetation, so that the surface of the ground is far more exposed in autumn than in spring. Adjacent areas that have been ploughed at any stage show minimal recolonisation by native plants, in particular *Lomandra* spp.

Aside from a single juvenile found under a stone, the only microhabitats in which *T. adelaidensis* have been found sheltering are vertical or near vertical holes. We suggest that the lizards are using spider holes, not digging their own burrows. The holes are perfectly circular, up to about 20 mm in diameter, lack any sign of excavated soil at the entrances and are indistinguishable from holes at the study site inhabited by lycosid and mygalomorph spiders. In at least one case a lizard inhabited a hole to which the lid of a trapdoor spider was still attached. Two large species of wolf spiders, *Lycosa stirlingi*, which makes a lid for its burrow, and *Lycosa gilberta*, which does not, have been identified at the study site as has a species of the trapdoor spider genus *Blakistonia* (probably *B. aurea*). Lycosids and their burrows are very common in the area. The lizards appear to make no obvious external modifications to the holes, save for a slight bevelling of the edges caused by their coming and going.

Home range and movements

We obtained few recaptures, and made only limited use of radio-tracking, so that our results are preliminary.

The area covered by a male that was radiotracked during spring encompassed 70m^2 and two burrows over a period of six days. Home range overlap occurs, as there were at least two other occupied burrows within the area that the lizard covered. A second, smaller male was fitted with the tracker, but when relocated after the first two-hour period it was moribund, apparently through exhaustion as it struggled to force itself into a hole but was prevented by the bulge of the transmitter. It was striking that, although shelter in the form of dense grass and *Lomandra* tussocks was all around, the lizard put all of its efforts into finding shelter in a hole.

The same male successfully tracked in November was caught again during March. It was still within the same area as the previous spring but in yet another hole. In another case, a burrow containing a female and young was abandoned and the female was discovered in another hole some 5 m from the original.

Only one of 22 captures during November-December was an adult female. All animals captured during spring/early summer were caught either by pitfall trapping or by hand, and so required the individual to be actively moving away from the burrow. However, of the adults captured during February-April one (a female) was captured by hand and 14 by "fishing" but pitfall trapping caught none, despite in excess of three weeks' intensive pitfalling in areas known to support a significant number of pygmy bluetongues. Of the adults caught during summer/autumn, 12 were females, and three were males, a reversal of the trend shown in spring/early summer.

The lop-sided sex ratio in our spring sample (only a single adult female caught) suggests much greater levels of male activity during the spring mating season. This is supported by the six predator kills collected during October-November, of which five were sexually mature males, while only one was an adult female. Males of other species of *Tiliqua* have increased activity levels relative to females during this time of year (Bull *et al.* 1991). The results so far indicate that both males and females may have relatively limited home ranges throughout most of the year, but in spring males appear to wander more widely (or at least, more often).

During November-December 1992, rainfall was above average and daily maxima ranged between 15°C and 36°C. Days when lizards were caught had maxima between 20°C and 36°C, and the time of capture varied from 08:15 to 19:30. All of the days on which pygmy bluetongues were caught were sunny at some stage, and so ground temperatures often would have exceeded the air temperatures. Traps were monitored after dusk on warm nights to check for nocturnal activity, but no lizards were captured at this time. Diurnal behaviour was also observed in captives, which showed no sign of nocturnal activity.

Diet

R40687 contained a large lepidopteran larva (a hadenine noctuid, probably *Persectania*, G. Brown pers. comm.); R40689 had the remains of an apparently identical larva, plus several leaves and flowers of the herb *Medicago*. R40744 contained three acridoid grasshoppers and the remains of a small beetle. Ehmann (1982), after examining specimens then in the SAMA collection, recorded cockroaches, ants, a spider, grasshopper and beetle, and some plants (*Dianella* seed, possible chenopod material). Wild lizards accepted grasshoppers offered as bait, and captive animals eat an omnivorous diet, including mealworms, crickets, chopped fruit and vegetables and raw egg. Thus the evidence to date indicates that *T. adelaidensis* eats a wide variety of invertebrate animals, but also includes plants in its diet.

The relative lack of movement away from the burrows, at least in late summer-autumn, suggests that at this time of year *T. adelaidensis* is probably a sit-and-wait forager. Burrow entrances are used as vantage points from which lizards would be able to make short forays after any prey detected nearby. The presence of leaves and flowers in the diet suggests wider foraging at least in spring. The study site suffered an outbreak of plague locusts (*Chortoicetes terminifera*) during the period of observation which may have influenced the lizards' behaviour. The sedentary behaviour may also be related to avoiding predation at the time of year when ground cover is sparsest.

Reproduction

All of the predator killed males (collected between 14/10/92 and 30/11/92) had testes that were enlarged and turgid or starting to regress. One of the trapped males had strings of dried seminal material protruding from the vent. The single dead female (R40744, collected 7/11/92) had four enlarged ovarian follicles (two left, two right). Together these data indicate a spring testicular maximum, with spermiogenesis and mating behaviour coinciding with ovulation. Other *Tiliqua* species syntopic with *T. adelaidensis*, *T. rugosa* and *T. scincoides*, are known to be spring breeders (Bourne *et al.* 1986; Shea 1993).

Neonates were first observed at the field site on 28 February, 1993, when four young were observed in the burrow of an adult female. Inspection of other burrows known to harbour females revealed other litters, litter size ranging 1-4 (mean 2.3). All juveniles examined at this time had raw pink umbilical scars indicating very recent birth. Two females which gave birth at Adelaide Zoo during mid-March had litter sizes of three and one. Within two weeks of their discovery, juveniles and sometimes adults abandoned the birth burrow. Juveniles were observed from late March alone in holes, sometimes much smaller than those used by adults.

The smallest animals caught in November were 66-70 mm SVL, while the largest young with distinct umbilical scars in May were 56-60 mm SVL. This implies that the *T. adelaidensis* born at the end of summer reach about 70 mm SVL by the end of spring of that year. This SVL is considerably smaller than the smallest breeding female recorded (SVL 96 mm), so that first breeding must occur no earlier than the second spring (approx. 20 months of age).

Behaviour

Tiliqua adelaidensis appears to be extremely sensitive to both movement and noise, making it difficult to observe lizards basking outside their burrows. Lizards bask with the back legs or tip of the tail remaining in the entrance of the burrow. From this position, they can back rapidly into their burrows if disturbed. Once inside, the lizards increase their security by turning the head sideways to force the snout and occiput against the sides of the burrow. Thus wedged in place, the lizards present only the armoured head to an intruder and seem almost invulnerable; any creature small enough to enter the hole is unlikely to be strong enough to harm or dislodge the lizard. The significance of the heavy osteodermal armour on the head seems to be associated with the use of the head as a combination anchor and doorstop.

Several behavioural attributes of captive lizards suggest why detection of the species in the field is difficult. The first is crypsis. When disturbed the lizards freeze: such stationary animals are well camouflaged against the reddish brown soil of the area, making them hard to see. The second is a reluctance to emerge into open spaces. In captive conditions the lizards spend almost all of their active time in holes or among litter. Thirdly, the lizards have a well-developed and unusual ability to move in confined spaces. Both in the field and in captivity they have been observed moving directly backwards into cover or down a burrow, avoiding a U-turn with its concomitant greater level of disturbance. The small, thin tails may facilitate this manoeuvre by not getting in the way as they might if longer or more massive. The body is unusually flexible, an attribute which probably assists in negotiating the confined spaces of burrows or tussocks. On several occasions, an animal was known to have entered a hole head first, turned around within the hole and emerged head first.

When disturbed or handled, this species has not yet been observed to exhibit the exaggerated defensive display employed by its larger relatives (Carpenter & Murphy 1978; Greer 1989). When handled the lizard will twist with great strength and agility, often gaping and endeavouring to bite in a similar fashion to other medium-sized skinks (e.g. *Egernia* spp.).

Possible Reasons for Decline

Tiliqua adelaidensis remained undetected in a well frequented part of South Australia for over three decades in spite of diligent searching by herpetologists. Based on our experience with the species, we suggest that two factors combined to hamper searchers – lack of information on its habits and habitat, and a probable real decline in the number of populations.

Ehmann (1982), based on his interpretation of the specimens and historical data, speculated that *T. adelaidensis* had inhabited a limestone-chenopod-mallee association. While the speculative nature of this assessment was noted by Ehmann himself, it nevertheless exerted a bias on many of the attempts to locate the species. The grassland habitat in which we have found the species is difficult to search casually for reptiles, and consequently has received little attention. This is especially so because most grassy terrains in this part of South Australia are assumed to be heavily disturbed, supporting only the most wide-ranging and ecologically tolerant reptiles. The distinction between native versus introduced grasslands has been important in locating populations of this species.

Even when one knows the correct habitat, the shy nature of the lizards makes them very difficult to find unless it is known exactly how and where to search. The crucial piece of information that allowed us to locate additional colonies was the discovery of their dependence on spider holes, information that was only acquired after we had located the initial population through good luck. The holes are difficult to see unless the observer is right next to them, so that any lizard occupant has plenty of warning of human approach and is out of sight by the time the hole has been noticed. Intensive field work had been going on for six weeks at the site before we observed any *T. adelaidensis* under natural conditions. However, having discovered the combination of habitat and microhabitat, we have been able to locate further populations of pygmy bluetongues in nearby areas. The species is now known to occur at six sites running from south of Burra to north of Hallett, the extremes separated by about 50 km.

The apparent rarity, caused by lack of attention to grasslands as a habitat, is probably coupled to a drastic reduction in abundance caused by pasture improvement and cropping. Native grassland similar to that in which the species occurs at Burra once extended south on to the Adelaide plains, but as prime agricultural land, was one of the first major habitats in South Australia to be cleared and ploughed. Ploughing permanently alters the vegetation and ground cover, converting a native, largely perennial flora into an introduced, largely annual one. In addition, ploughing would destroy the burrows, killing lizards directly and leaving the survivors without shelter and at the mercy of predators. The fact that most specimens were collected last century may simply be correlated with the fact that this was when most of their habitat was being converted to agriculture.

Remaining native grassland is now extremely patchy, and the remnants have generally been heavily invaded by introduced annuals. However, populations of pygmy bluetongues have now been found in some of these remaining pockets, and provided that land use is not changed, these colonies may be relatively secure. Further work is focussing on finding the extent of the current range of the pygmy bluetongue, approximating population size within these areas, and confirming many of the subjective ideas developed during the course of this first season's field work. This will lead to an accurate assessment of the status of the species.

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Appendix 1

Plant diversity at Tiliqua adelaidensis *study site. Species noted during the general search but not recorded during step-pointing are indicated by (*). Taxonomy modified from Jessop (1989).*

Species	Common Name	Annual/ Perennial	% Ground Cover
Native species			
Chenopodiaceae			
Atriplex semibaccata	berry saltbush	P	*
Enchylaena tomentosa	ruby saltbush	P	*
Maireana aphylla	cotton-bush	P	*
M. enchylaenoides	wingless bluebush	P	*
M. trichoptera	mallee bluebush	P	*
Salsola kali	roly-poly	A	*
Amaranthaceae			
Ptilotus spathulatus	pussytail	P	<1
Oxalidaceae			
Oxalis perennans	native sorrel	P	<1
Geraniaceae			
Erodium crinitum	blue storks bill	P	*
Euphorbiaceae			
Euphorbia drummondii	caustic weed	P	*
Rhamnaceae			
Cryptandra amara	long-flower cryptandra	P	*
Thymeliaceae			
Pimelea micrantha	silky riceflower	P	*
Rubiaceae			
Asperula conferta	common woodruff	P	*
Convolvulaceae			
Convolvulus erubescens	Australian bindweed	P	<1
Campanulaceae			
Wahlenbergia luteola	bluebell	P	*
Goodeniaceae			
Goodenia pinnatifida	cut-leaf goodenia	P	*
Asteraceae			
Leptorhynchos squamatus	scaly buttons	P	*
Minuria leptophylla	minnie daisy	P	*
Vittadinia cuneata	New Holland daisy	P	*
V. gracilis	woolly New Holland daisy	P	2
Liliaceae			
Lomandra effusa	scented mat-rush	P	1
L. multiflora	stiff mat-rush	P	4
Juncaceae			
Juncus bufonius	toad rush	P	<1
J. kraussii	sea rush	P	<1
Poaceae			
Aristida behriana	brush wire-grass	P	*
Danthonia caespitosa	white-top	P	1
D. pilosa	velvet wallaby grass	P	3
D. racemosa	wallaby grass	P	<1
Stipa blackii	crested spear grass	P	<1
S. eremophila (possibly *S. puberula*)	desert spear grass	P	8
S. nodosa	spear grass	P	3
Themeda triandra	kangaroo grass	P	<1
Introduced			
Polygonaceae			
Rumex dumosus	wiry dock	P	*
Fabaceae			
Medicago littoralis	strand medic	A	6
M. minima	woolly burr medic	A	3
Trifolium angustifolium	narrow-leaf clover	A	3
T. arvense	hares foot clover	A	2
Boraginaceae			
Echium plantagineum	salvation Jane	A	8
Neatostema apulum	hairy sheepweed	A	7
Lamiaceae			
Marrubium vulgare	horehound	A	*
Salvia verbenaca	wild sage	P	14
Asteraceae			
Arctotheca calendula	Cape weed	A	*
Carthamus lanatus	saffron thistle	A	*
Hypochoeris glabra	smooth catsear	A	<1
Sonchus oleraceus	common sow-thistle	A	*
Iridaceae			
Gynandriris setifolia	thread iris	A	<1
Poaceae			
Avena barbata	bearded oat	A	23
Brachypodium distachyon	false brome	A	*
Bromus rubens	red brome	A	1
Hordeum glaucum	northern barley grass	A	*
Lolium perenne	perennial ryegrass	A	<1
Vulpia muralis	rats-tail fescue	A	2